rather out of date at the present time, are the following: In Greely's "*American Weather*:" "Continuance of Daily Mean Temperature above 50° F.," Chart IX (Lines are drawn for the periods of months; figures are given for days); "Continuance of Daily Mean Temperature below 32° F.," Chart X; "Variability of Temperature for January," Chart XI (mean diurnal; lines for 1° intervals). In Waldo's "*Elementary Meteorology*": "Absolute Amplitude of Shade Temperatures (after Greely)," Fig. 99; "Variability of Average Daily Temperatures in January in the United States (after Greely)," Fig. 101; "Relative Frequency of Falls of Temperature of over 20° in 24 hours (after Russell)," Fig. 102. In *Bulletin Q*: "Mean Maximum Temperatures for July," Pl. XV; "Mean Minimum Temperatures for January," Pl. XVI; "Absolute Range in Monthly Mean Temperature, January," Pl. XVII; "Absolute Range in Monthly Mean Temperature, July," Pl. XVIII.

The earliest publication of temperature charts of the United States for "popular" use seems to have been that of Dr. Charles Denison, who, in 1884 (Rand, McNally & Co., Chicago), issued a set comprising an annual and four seasonal climatic maps, showing, by lines and by colors, the distribution of temperature, rainfall, cloudiness, and relative humidity, and by arrows, the prevailing winds. The maps and tables were "compiled from data of the Signal Service Bureau," obviously very fragmentary at that early date. Reviewed by W. M. Davis, in *Amer. Met. Journ.*, vol. 1, 1884–85, pp. 545–546. A so-called "popular edition," with additions, was published in 1893 (large 8°, 1893, pp. 47).

C. ANNUAL AND MONTHLY ISOTHERMAL CHARTS OF THE WORLD.

No study of the temperatures of any single country is complete unless it includes a comparison with those of other parts of the world. For this reason the following references to the present standard world temperature charts are here added.

The one uniform and complete series of annual and monthly isothermal charts is the "Challenger" set, originally published in the *Report on Atmospheric Circulation*, "*Challenger*" *Reports, Physics and Chemistry*, Vol. II, Edinburgh, 1889, and all reproduced in the *Atlas of Meteorology*, pls. 1 and 3 (text pp. 7, 9–10). The mean annual, January, and July charts have since been reproduced in a large number of publications. These charts are based on observations taken during the same period of 15 years, 1870–1884, and a uniform reduction formula of 1° F. for 270 ft. (1° C. for 200 meters).[5]

No newer world charts of the mean annual maxima, mean annual minima, and mean annual extreme range than those of Dr. van Bebber, originally published in 1893, are available.[6]

These three charts are reproduced, in colors, in the *Atlas of Meteorology*, pl. 2, text, pp. 8–9, with the statement that "some corrections have been kindly communicated by the author" (i. e. Dr. van Bebber). Charts of this sort are obviously constructed with great difficulty, and it is hardly to be expected that a new series will be prepared in the near future.

The "standard" world charts of mean annual ranges and of isanomalous temperatures were constructed by former students of Professor W. M. Davis, of Harvard University, and under his direction. The mean annual range chart, based on the "Challenger" January and July isothermal charts, was the work of J. L. S. Connolly,[7] and is reproduced, in colors, in the *Atlas of Meteorology*, pl. 2, text, p. 8. It also appears in Davis's "*Elementary Meteorology*," fig. 18, and elsewhere. The isanomalous charts were constructed by S. F. Batchelder, and included the mean annual, January and July isonomalies.[8]

The January and July charts were the only ones printed, and these are reproduced, in colors, in the *Atlas of Meteorology*, pl. 2, text, p. 8, in Davis's "*Elementary Meteorology*," figs, 16 and 17, and elsewhere. The original chart showing the mean annual isanomalous lines, which has never been published, is in the Climatological Laboratory of Harvard University.

In the study of the larger temperature conditions of the United States, especially in relation to those of the world as a whole, the "thermal regions" of the late Dr. A. J. Herbertson are very useful.[9]

Dr. Herbertson's three essential maps are reproduced, on a large scale, in the series of *Oxford Wall Maps*.[10]

The map of the thermal regions of the world shows 10 different regions, indicated by different colors and divided according to the characteristics of their seasons, the distinguishing temperatures being over 68°; 50°–68°; 32°–50°; and below 32° (F.). These are actual temperatures, not reduced to sea level. The same wall map also shows the mean actual temperatures for January and for July, in colors, the critical actual temperatures being the same as those used in the thermal regions. Areas over 68° are pink; between 50° and 68°, yellow; between 32° and 50°, green; and below 32°, blue. On all three maps the critical *sea-level* isotherms of the "Challenger" charts are shown, for purposes of comparison between sea-level and actual temperatures.

551.510.5

LEVEL OF CONSTANT AIR DENSITY.[1]

By W. J. HUMPHREYS, Professor of Meteorological Physics.

[Weather Bureau, Washington, D. C.]

Sir Napier Shaw says[2] that at the level of 8 kilometers the density of the air "is equal all over the globe at all seasons of the year." Statistical evidence of the truth of this statement occurs in density-elevation tables by W. H. Dines,[3] and by Gregg.[4] I was unable, however, to find any general or theoretical proof of it, and therefore tried to prove it myself; and as this proof is both short and easy it may be worth passing along, even though it must bear the warning label "perhaps not new."

As is well known, both the composition and the sea-level pressure of the atmosphere are roughly constant from season to season and from place to place. Clearly

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[5] Historical, bibliographical, and descriptive notes on various temperature charts will be found in the *Atlas of Meteorology* text, pp. 6–10. Reference may also be made to *E. W. Woolard*: "Historical Note on Charts of the Distribution of Temperature, Pressure, and Winds over the Surface of the Earth," *Month. Weather Rev.*, July, 1920, 48, 408–411.

[6] W. J. van Bebber: "Die Verteilung der Warmeextreme über die Erdoberfläche," *Pet. Mitt.*, vol. 39, 1893.

[7] J. L. S. Connolly: "A New Chart of Equal Annual Ranges of Temperature," *Amer. Met. Journ.*, vol. 10, 1893, 94, pp. 505–506, 1 ch.

[8] S. F. Batchelder: "A New Series of Isanomalous Temperature Charts, based on Buchan's Isothermal Charts," *ibid*, vol. 10, 1893–94, pp. 451–474, chs. 2.

[9] A. J. Herbertson: "The Thermal Regions of the Globe," *Georgr. Journ.*, vol. 40, 1912, pp. 518–532; reprinted in *Mo. Weather Rev.*, vol. 42, 1914, pp. 286–289; reviewed by *R. De C. Ward*: "A Note on the Classification of Climates," *Bull. Amer. Geogr. Soc.*, vol. 46, 1914, pp. 108–116.

[10] Oxford University Press; 60 x 40 inches, mounted on cloth. Three maps on one sheet.

[1] Presented at meeting of American Meteorological Society, Washington, D. C., Apr. 21, 1921.

[2] *Nature*, 1920. 106:436.

[3] *Geophys. Memoirs*, No. 13, p. 63, 1919.

[4] MONTHLY WEATHER REVIEW, Jan., 1920. 48:10.

then, to this approximation, the sea level density of the air varies inversely as the absolute temperature. But an increase of the temperature of the air not only decreases the surface density owing to expansion, but also, as a result of this expansion, increases the pressure at each level above the surface.

Furthermore, the ratio of both seasonal and latitudinal temperature changes to the absolute temperature are roughly constant from the surface up to the stratosphere. Through this height, therefore, a temperature gain tends, on the one hand, to decrease the density of the air by thermal expansion, and, on the other, to increase it by mechanical compression. Clearly, then, that level at which the one tendency exactly balances the other must be a level of constant density.

To determine this level, let v, p, ρ, and T, be the volume, pressure, density, and absolute temperature, respectively, of a quantity of air at the height h above sea level, and H the height of the homogeneous atmosphere *above* h. Then, up to such height, that is, to the top of the troposphere, as $\Delta T/T$ is constant

$$\frac{\text{pressure contraction}}{v}=-\frac{\delta v}{v}=\frac{\delta p}{p}=\frac{h\rho g\Delta T/T}{H\rho g},$$

and

$$\frac{\text{temperature expansion}}{v}=\frac{\Delta v}{v}=\frac{\Delta T}{T}.$$

But, as explained, density is constant where

$$-\frac{\delta v}{v}=\frac{\Delta v}{v},$$

or where

$$\frac{h\rho g\Delta T/T}{H\rho g}=\frac{\Delta T}{T};$$

that is where

$$h=H$$

But $H=8$ kilometers, about. Hence, the level of constant density is roughly 8 kilometers above sea level, as statistically shown in the papers cited above.

Below this level, density grows greater and above it less, both with the waning of summer and with the increase of latitude; similarly, it grows less below this level and greater above it, both with the passage of winter and with the decrease of latitude.

VARIATIONS IN THE DENSITY OF AIR.[1]

By A. JAQUEROD and C. BOREL.

[Reprinted from *Science Abstracts*, 1921, 24: 217.]

The authors describe briefly some refined determinations of the density of air, made by them at Neuchâtel, with the object of investigating the unexplained variations in the density pointed out by Morley as long ago as 1875. The law of Loomis-Morley is confirmed, namely, that the maximum density is found with samples of air taken when the atmospheric pressure is a minimum, and *vice versa*. Differences of composition do not seem sufficient to explain these variations, and Guye has suggested that the cause is to be found in the presence of ultramicroscopic dust. To test this the authors propose to experiment with air from which dust has been removed electrically. Samples of air obtained by aeroplane from altitudes between 2 km. and 3 km. have been tested and appear to be subject to the same variations of density as the surface air.—*M. A. G.*

[1] *Archives des Sciences*, Paris, Sept.-Oct., 1920, 2: 411-413.

THE ENERGY OF CYCLONES.

[Reprinted from *Nature*, London, March 3, 1921, pp. 11-12.]

In the recent discussion in *Nature* on the energy of cyclones [1] no mention has been made of tropical cyclones, although these are the most remarkable phenomena of their kind.

It is impossible to apply to these cyclones the theories which ascribe the energy of the rotating-wind system to the re-adjustment of equilibrium of warm and cold masses of air within that system, since in the cyclones of the Tropical Zone temperature and humidity are symmetrically distributed. In these cyclones warm and cold sectors do not exist. The Indian meteorologists Henry Blanford, Sir John Eliot, *Fr.* Chambers, and W. T. Willson have published papers on the cyclones of the Bay of Bengal and the Arabian Sea, giving a full explanation of their origin and development. These very important works no longer receive the attention they deserve. They also throw much light upon the source of energy in these cyclones. I endeavored to make a rough calculation of the energy contained within one of these whirls, taking into account the preceding pressure distribution over the hurricane region, and the results were in good agreement with the observed wind forces. I should therefore like to direct attention to this work.

The calculation was based upon observations of the Backergange cyclone. It is given in my *Lehrbuch der Meteorologie* (1901 edition, *p. 579*, footnote), as well as in a paper, "Remarks on the origin of (tropical) cyclones" (*Meteorologische Zeitschrift*, 1877, Aug., p. 311). My calculation has no application to the cyclones of middle and higher latitudes, as it presupposes simple whirls like the symmertical cyclone of the Tropics.—*J. von Hann*, Vienna, Feb., 1921.

[1] Reprinted in MO. WEATHER REV., Jan., 1921, 49: 3-5.

A REVIEW OF SOME OF THE LITERATURE ON THE SUNSPOT-PRESSURE RELATIONS.

551.590,2 : 551.54

By ALFRED J. HENRY, Meteorologist.

[Weather Bureau, Washington, May, 1921.]

SYNOPSIS.

In the minds of some meteorologists there is an impression amounting almost to conviction in a few cases that there is a distinct response in terrestrial barometric pressure to changes in solar energy as manifested in the changing spottedness of the sun. This study was carried along in connection with an inquiry into the broader relations of sunspots to terrestrial weather. If there is a distinct response in the pressure then we may expect corresponding changes in the temperature, wind movement, and other meteorological elements.

The evidence submitted by various writers on the subject, beginning with Meldrum in 1872, is examined in as much detail as is now possible and the results reached are given in the "conclusions" at the end of the paper.

At the Brighton meeting of the British Association in 1872, Mr. Charles Meldrum, Director of the Observatory of Mauritius, made the statement that for the area comprised between the Equator and 25° South Latitude, and